Nanometer scale InAs/AlGaSb quantum structures

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Low-dimensional electron systems are of interest for studying fundamental properties and device applications. To substantiate the size quantization effect, the electrons should be confined in a dimension comparable to the Fermi electron wavelength. Furthermore, the elastic mean free path must be kept long in order to resolve the quantum states. Recently, there has been remarkable progress in the fabrication of GaAs quantum devices using a split-gate approach. However, the InAs/AlGaSb system offers a few properties that are advantageous for realizing low-dimensional devices. For example, larger inter-subband energy separations as results of a smaller effective mass and a larger conduction band discontinuity.

This presentation will review our recent progress in the fabrication of InAs quantum rings/wires/dots and discuss their magnetotransport and tunneling characteristics. We have successfully developed novel fabrication processes using electron-beam lithography for defining InAs quantum wires with 30 nm minimum feature size. We have demonstrated that the fabrication techniques are versatile and flexible: a resist pattern can be defined by e-beam lithography, and subsequently the pattern is transferred to the InAs quantum well either by RIE process or by selective wet chemical etching. The former technique produces stand-alone InAs wires/dots with abrupt sidewalls and a square confinement potential, while the latter results in buried quantum channels. We have fabricated many ultrasmall devices with different geometries, including hallbars, Aharonov-Bohm quantum rings and quasi-zero-dimensional double-barrier resonant tunneling quantum dots. Magnetotranposrt characterization on a series of hallbars and quantum rings demonstrates that the electron transport in these quantum structures is in the quasi ballistic regime at 4K. To probe and characterize quantum dots, we have designed and fabricated a cryogenic scanning tunneling microscope. Features observed in the tunneling spectroscopy due to Coulomb blockade are clearly identified.